







Cognitive Online RPI Plasmagram Ranking Algorithm

### **CORPRAL:**

Processing Radio Plasma Imager Plasmagrams
Utilizing Hierarchical Segmentation



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### **Outline**



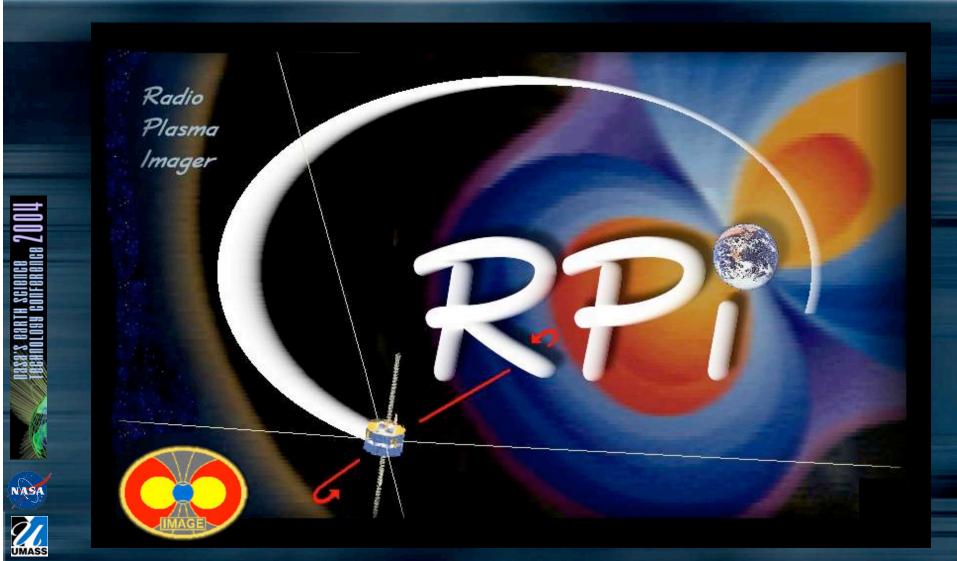
- Radio Plasma Imager (RPI)
  - Operations
  - Data stream and need for exploration
- Data Exploration with CORPRAL
  - Problem statement and approach
  - Processing example
  - Current results
- Hierarchical Segmentation
  - Principles and strengths
  - Early results on RPI data
- Summary





### Radio Plasma Imager

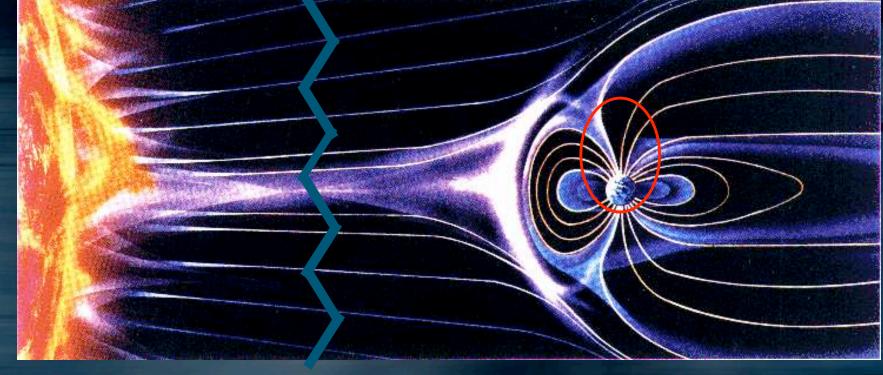




### **IMAGE Mission**



#### Magnetosphere



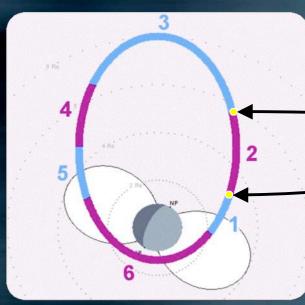
NASA

http:/image.gsfc.nasa.gov

**IMAGE** orbit

### **RPI Mission Planning**

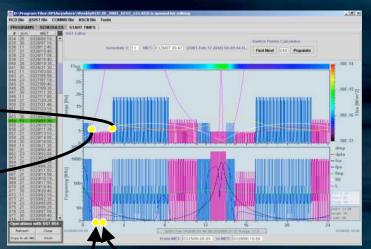




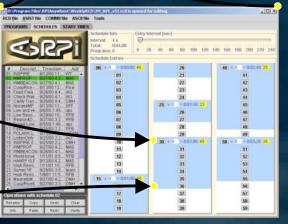
**Six Orbit Regions** 



**EdRPI Program Editor** 



**EdRPI Start Time Editor** 

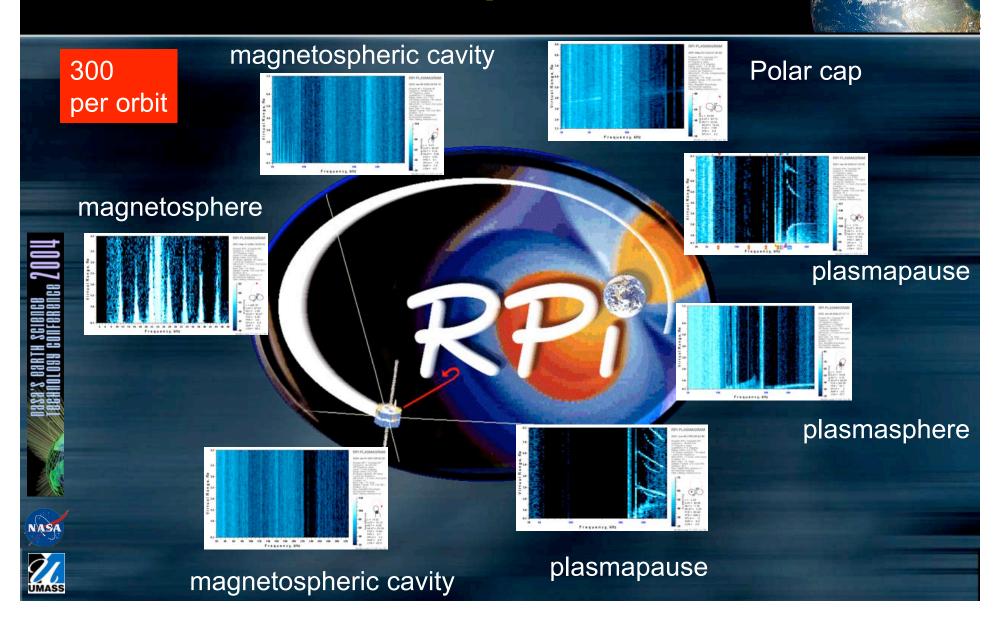


**EdRPI Schedule Editor** 



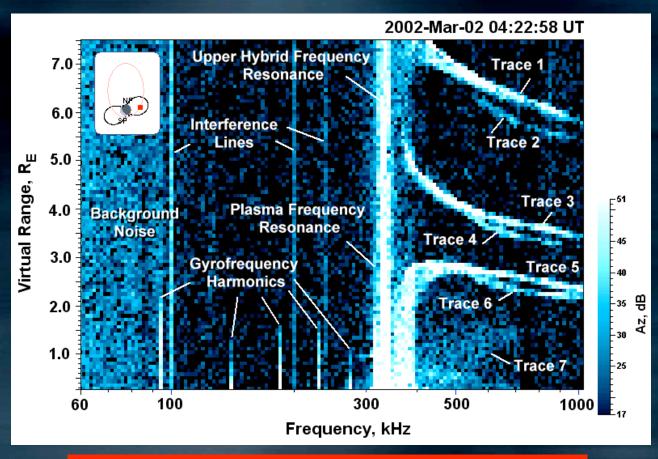


## RPI Dataset and Exploration Needs



### **RPI Plasmagram**









<20% of RPI plasmagrams have echo traces

~900,000 plasmagrams acquired

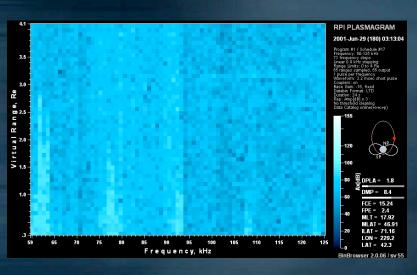
~600 plasmagrams a day

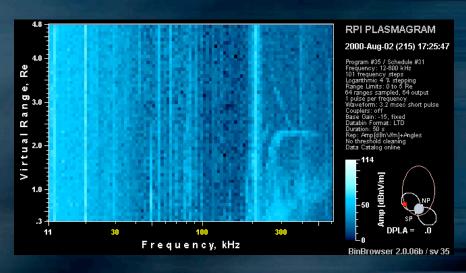
#### How hard is the task?



**VERY** 

- Number and shapes of traces are unknown
- False alarms and trace gaps due to low signal to noise ratio
- Range jitter
- Intersecting, faint, and spread traces
- Inconsistency (strong traces becoming faint with frequency,
   faint traces in vicinity of strong traces, etc.)







TRACE MIX



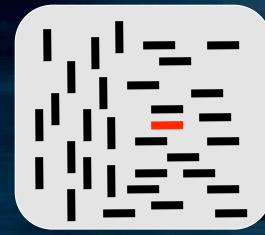


### Our choice: Early Vision

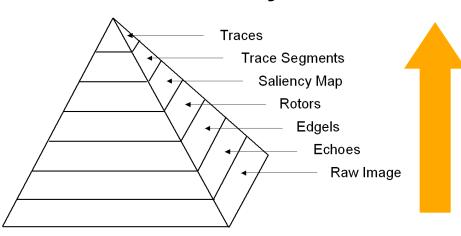


#### a.k.a. PRE-ATTENTIVE VISION

- Responsible for monitoring current view without willful attention to particular elements.
- "Pops up" objects that may require attention and action such as movement of eyes, head or body.



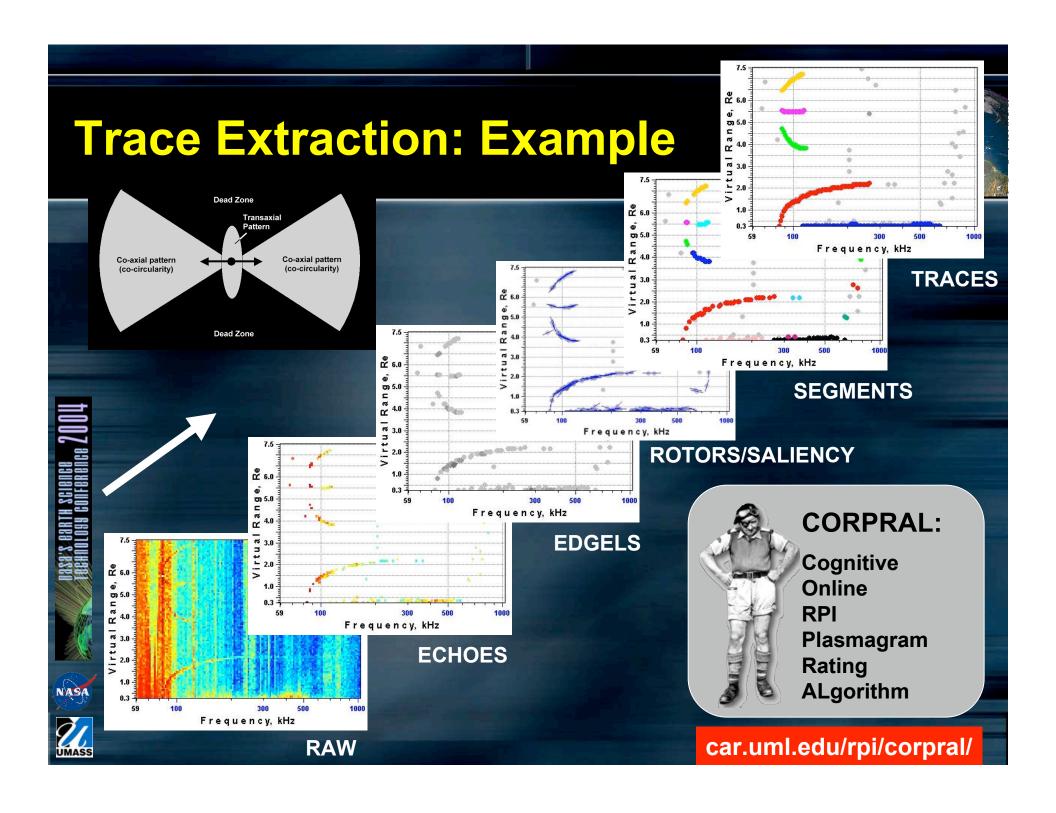
#### **Marr's Pyramid of Perception**



**Bottom-up process** 

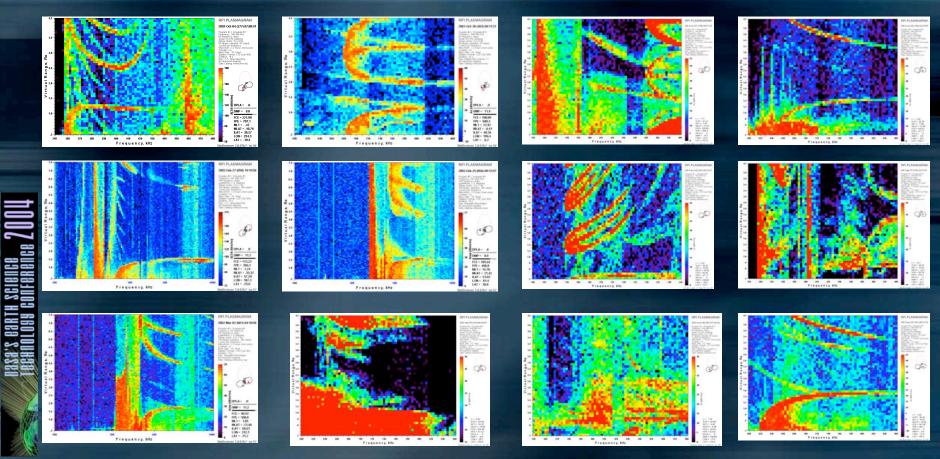






### **Data Exploration Scenarios**







Some of CORPRAL-rated plasmagrams with 6 traces or more



### **CORPRAL Statistics**



Total plasmagrams: ~900,000

CORPRAL-rated plasmagrams: ~150,000 (17%)

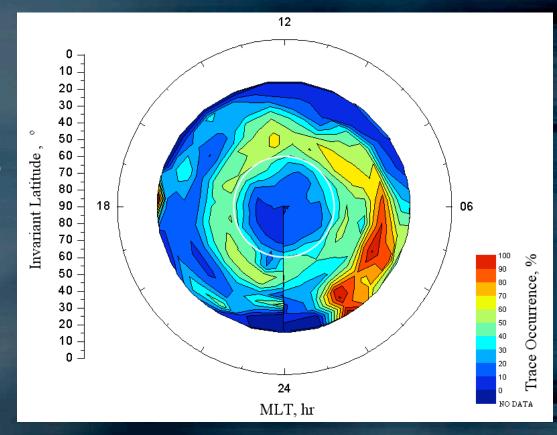
Sample performance: 1420 plasmagrams
May 2001

**Trace occurrence: 11%** 

**Processing accuracy: 97%** 

Positive PV: 91%

**Negative PV: 98%** 

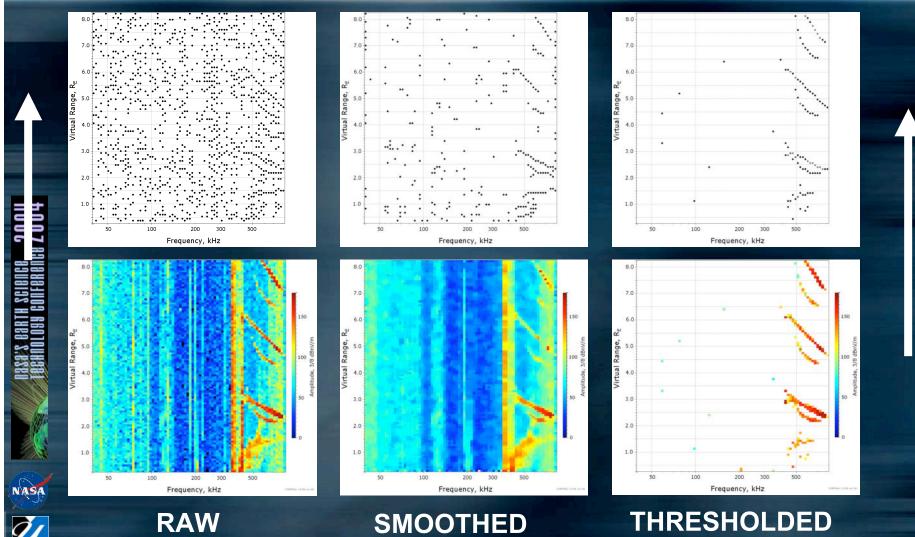






### **Echo Detection in CORPRAL**







A Hierarchical Segmentation is a set of image segmentations that:

- i. consist of segmentations at different levels of detail, in which
- ii. the coarser segmentations can be produced from merges of regions from the finer segmentations, and
- iii. the region boundaries are maintained at the full image spatial resolution.







For a Segmentation Hierarchy of sufficient quality and resolution, an object of interest will:

- be represented by multiple image segments at finer levels
- be merged into the background at coarser levels
- be represented as a single segment at some intermediate level





### **Hierarchical Segmentation**



#### Hierarchical Segmentation (HSEG) algorithm:

- 1. Initialize segmentation with a pre-segmentation, or initialize each pixel as a separate region.
- 2. Calculate dissim\_val between adjacent region pairs (if spclust\_wght > 0.0, also between spatially non-adjacent region pairs).
- 3. Let threshold equal the smallest dissim\_val between adjacent regions. Then set prev\_max\_threshold = 0.0 and max\_threshold = threshold.





### **HSEG** (cont'd)

- 4. If spclust\_wght = 0.0, go to step 7. Otherwise, merge all pairs of regions with dissim\_val = 0.0 or dissim\_val < spclust\_wght×max\_threshold.
- If nregions ≤ chk\_nregions, go to step 11.
   Otherwise update dissim\_val's as necessary.
- 6. Let threshold equal the smallest dissim\_val between spatially adjacent regions. If threshold > max\_threshold, set prev\_max\_threshold = max\_threshold and then set max\_threshold = threshold.





- 7. Merge all pairs of spatially adjacent regions with dissim\_val ≤ max\_threshold. Update dissim\_val's as necessary between each merge.
- 8. If nregions ≤ chk\_nregions, or if spclust\_wght = 0.0, go to step 11. Otherwise, update dissim\_val's as necessary between all pairs of regions.
- 9. Merge all pairs of spatially adjacent or nonadjacent regions with dissim\_val ≤ spclust\_wght ×max\_threshold. Update dissim\_val's as necessary between each merge.





11. If nregions ≤ conv\_nregions, save results and STOP. If this is the first time executing step 11, save results and go to step 6. Otherwise, calculate tratio = max\_threshold / prev\_max\_threshold. If tratio ≥ convfact save results and go to step 6. Otherwise, just go to step 6.



### HSEG (cont'd)



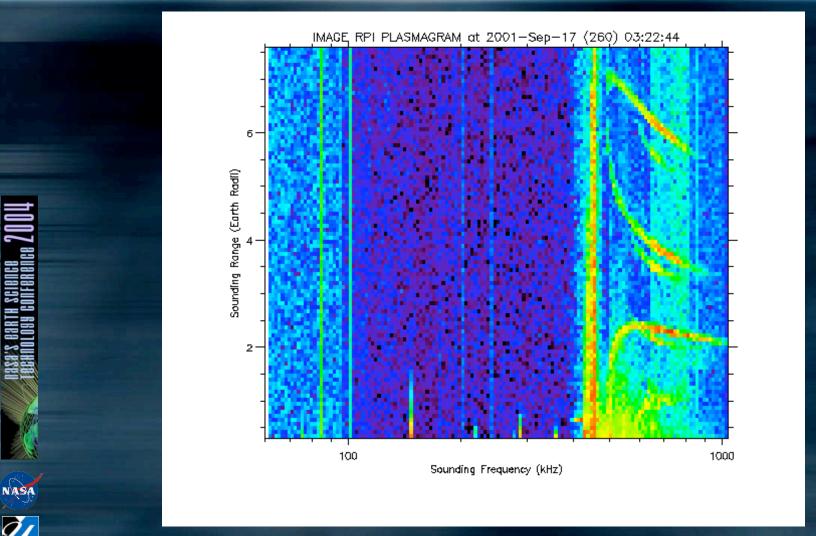
This study uses a dissimilarity criterion based on "mean squared error" (MSE):

$$d_{MSE}^{1/2}\left(X_{i}, X_{j}\right) = \left[\frac{n_{i}n_{j}}{\left(n_{i} + n_{j}\right)}\left(\mu_{i} - \mu_{j}\right)\right]^{1/2}$$

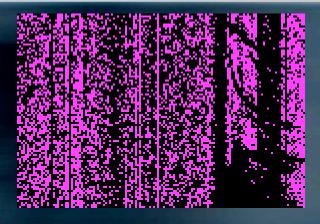
where  $X_i(X_j)$  is the subset of the image X corresponding to region i(j),  $n_i(n_j)$  is the number of pixels in region i(j), and  $_i(_j)$  is the mean value of region i(j).

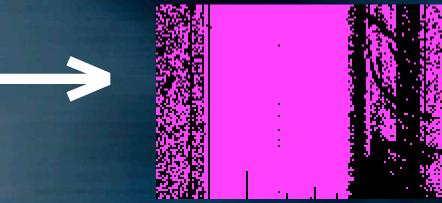








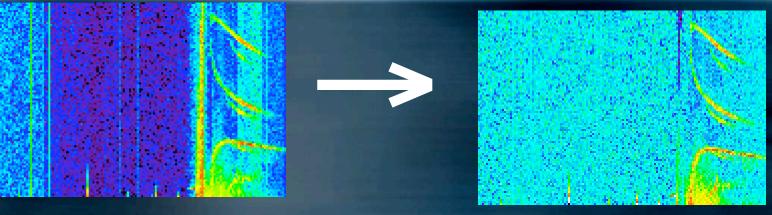




Level 20	Level 21			
6 Regions	5 Regions			
1882 Conn. Reg.	1048 Conn. Reg.			
0.975 Bound./Area	0.310 Bond./Area			



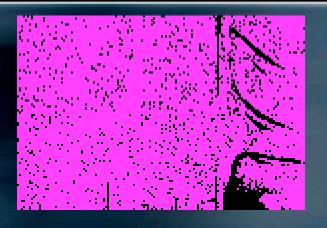


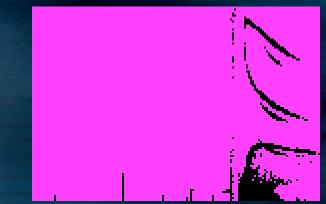


To compensate for different background values at different frequencies, subtract column (Frequency) Median Value from each column – and add a bias back sufficient to create an all positive value image.





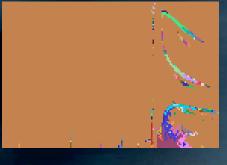




Level 27	Level 28			
6 Regions	5 Regions			
1018 Conn. Reg.	213 Conn. Reg.			
0.471 Bound./Area	0.066 Bond./Area			



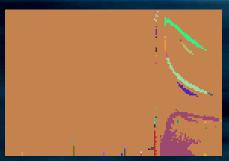




Level 7



Level 10 (*spclust\_wght* = 0.0)

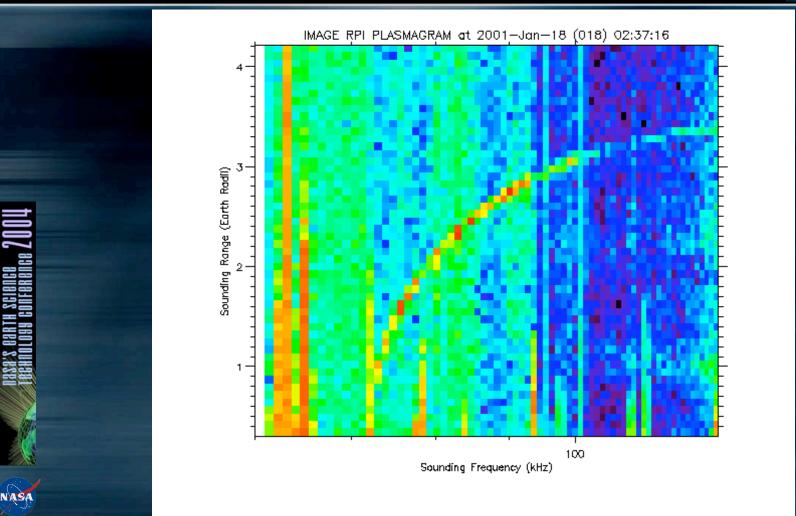


Level 13

Level	6	7	8	9	10	11	12	13
Regions	331	136	97	90	83	67	60	46
Thresh	2.0	6.7	8.5	9.2	10.0	11.9	13.0	15.2

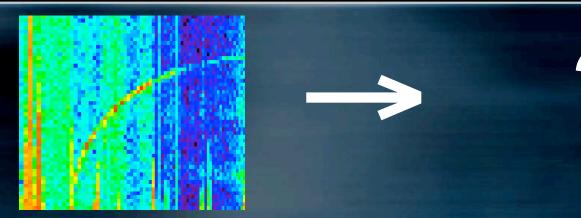












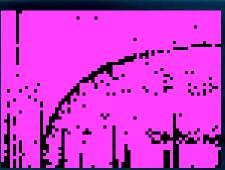
To compensate for different background values at different frequencies, subtract column (Frequency) Median Value from each column – and add a bias back sufficient to create an all positive value image.











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COCO
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20 MB
ALESS TEEN
THE REAL PROPERTY.
1/V/III
10V/35
15/3/64

Level 13	Level 14			
6 Regions	5 Regions			
755 Conn. Reg.	265 Conn. Reg.			
0.856 Bound./Area	0.309 Bond./Area			







Level 1



Level 4 (spclust\_wght = 0.0)



Level 7

Level	1	2	3	4	5	6	7
Regions	201	161	153	133	130	119	85
Thresh	3.7	5.0	5.7	7.1	8.0	9.5	13.8



#### CORPRAL

- ■In operation since 2002
- Uses a pre-attentive visions model to find traces
- •Quick survey shows good accuracy
- New ways to use CORPRAL ratings are emerging

#### Hierarchical Segmentation

- Idea and approach defined
- Application to RPI still in early exploratory stage
- Hope 2-dimensional analysis will help reduce CORPRAL false positives



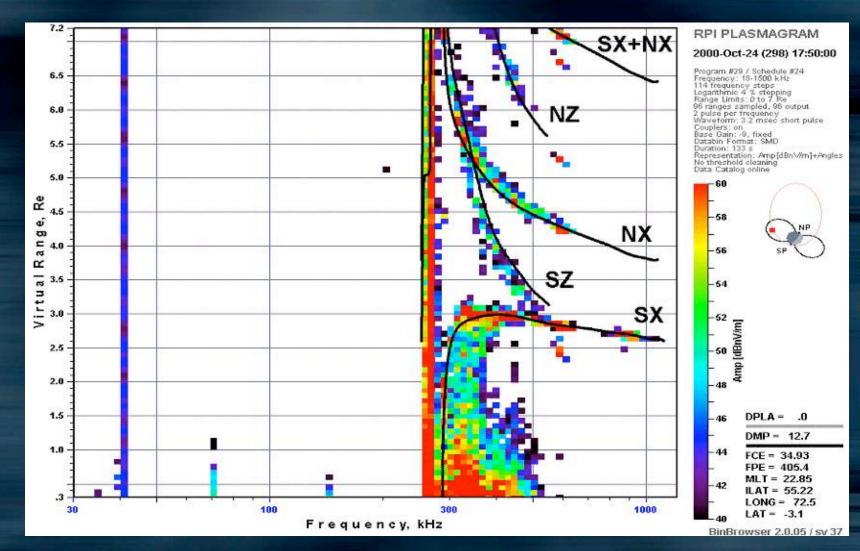
## **BACKUP**





### **Instead of Attention-driven...**





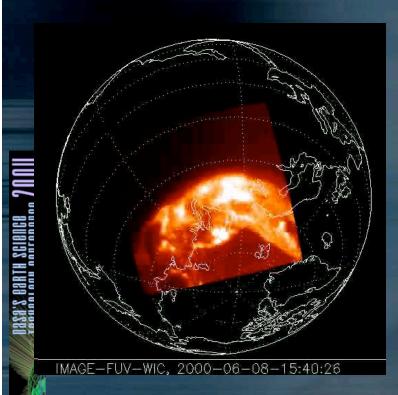




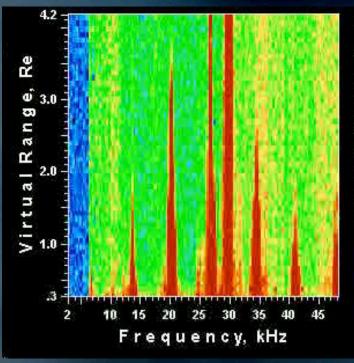


### **RPI Data Stream**









#### RPI PLASMAGRAM

2001-Mar-31 (090) 18:05:03

Program #38 / Schedule #30
Frequency: 3-48 k Hz
161 frequency: steps
Linear 0,3 k Hz stepping
Range Limits: 0 to 4 Re
56 ranges sampled: 56 output
1 pulse per frequency
Waveform: 3.2 misec short pulse
Counters: 66 Couplers on Base Gain - 15, fixed Batabin Formas LTD Duration 49 s Rep. Amp[dBn\/m]+Angles No threshold cleaning Data Catalog online



PostPro1 1.3.12 / sv 53

2 hours of RPI data





#### **Feature Extraction**



- Top-down
  - Hough transform
    - Geometric shapes
  - Feed-forwardneural networkclassifier
    - Fixed-shape objects, e.g. volcano
    - Involves training

- Bottom-up
  - Region Growing
    - Distinct shape objects and areas, e.g. forest
  - Deformable-contour, a.k.a. snakes, elastic arms, energy minimization, active contour
    - Varying shape objects
      - Line networks (roads, rivers, etc.)
      - Stones



